3D computational hierarchical model of wood: From microfibrils to annual rings

Qing, Hai

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3D Computational Hierarchical Model of Wood
From Micofibril to Annual Rings

Hai Qing & Leon Mishnaevsky Jr.

Materials Research Division, Risø National Laboratory for Sustainable Energy, Technical University of Denmark, DK-4000 Roskilde, Denmark

ABSTRACT

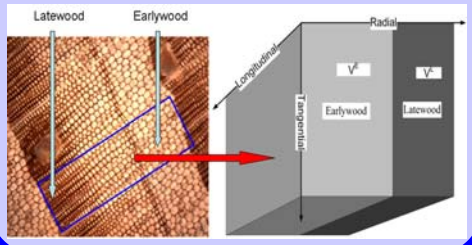
Based on the structures of wood at several scale levels, a 3D hierarchical numerical analytical model is developed, and the influence of microfibril angle, the shape of the cell and the wood density on the elastic properties is studied. Good agreement can be obtained compared with experimental data.

INTRODUCTION

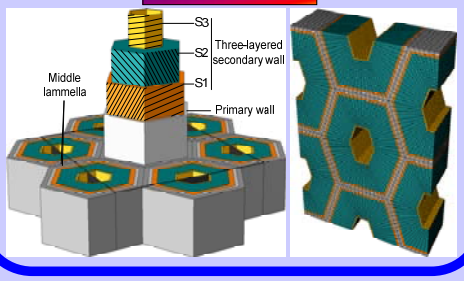
- Wood is one of oldest and now still is one of most widely used engineering materials.
- The problem of prediction of strength and reliability of wooden parts more significant for practical applications
- The study of the mechanical properties and microstructure-strength relationships of wood can help people to design and to improve composites and other man-made materials.

COMPUTATIONAL MODEL

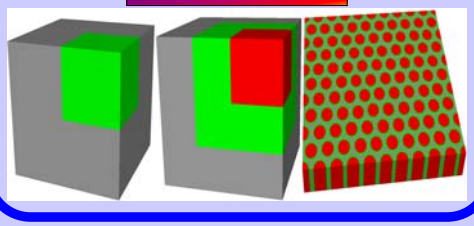
AT MACROLEVEL



AT MESOLEVEL

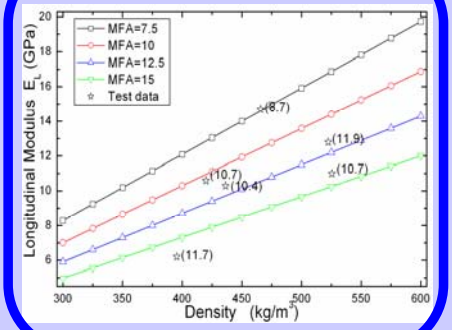


AT SUBMESOLEVEL

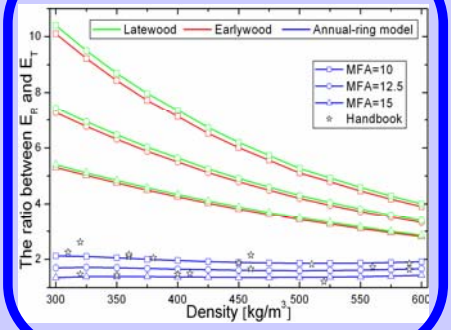


SIMULATION RESULTS

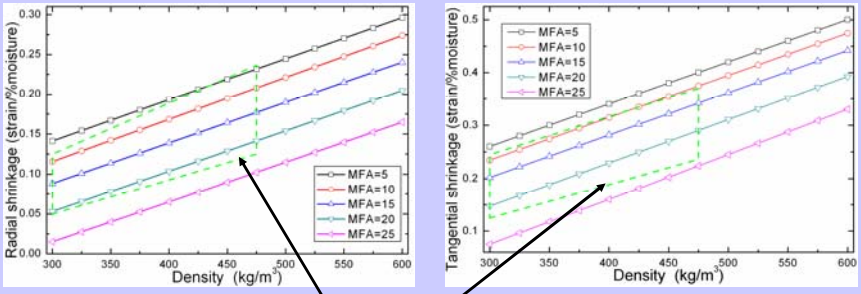
LONGITUDINAL MODULUS



TRANSVERSE ANISOTROPY



SHRINKAGE PROPERTIES



CONCLUSIONS

- Based on the structures of wood at several scale levels, a 3D hierarchical computational model of wood is developed:
  - At macrolevel, an improved rule-of-mixture model, based on 3D orthotropic stress-strain relations and taking into account the compatibility of deformations at the interface of two phases and equilibrium of tractions at phase boundaries, is proposed for the analysis of the effect of the annual rings structure on the properties of softwood.
  - At mesolevel, the layered honeycomb-like microstructure of cells was modeled as a 3D unit cell with layered walls. The finite element model was generated in the preprocessing FE software PATRAN using the parametric modeling technique.
  - At submesolevel, each of the layers forming the cell walls was considered as composite, taking into account the experimentally determined microfibril angles and chemical contents. The elastic properties of the layers were determined through FEM.
- With the use of the developed hierarchical model, the influence of the microstructure, including microfibril angles, the cell shape angles and the wood density (annual ring structure) on the elastic properties of softwood was studied. The computational results are compared with experimental data, and good agreement can be obtained.

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